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For: A TELECOMMUNICATIONS METHOD AND SYSTEM USING NON-GEOSYNCHRONOUS SATELLITES AND IN WHICH CALLS CAN BE HANDED OVER FROM ONE SATELLITE TO ANOTHER

DECLARATION

I, Andrew Scott Marland, of 35, avenue Chevreul, 92270 BOIS COLOMBES, France, declare that I am well acquainted with the English and French languages and that the attached translation of the French language PCT international application, Serial No. **PCT/FR00/01824** is a true and faithful translation of that document as filed.

All statements made herein are to my own knowledge true, and all statements made on information and belief are believed to be true; and further, these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any document or any registration resulting therefrom.

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A TELECOMMUNICATIONS METHOD AND SYSTEM USING NON-GEOSYNCHRONOUS SATELLITES AND IN WHICH CALLS CAN BE HANDED OVER FROM ONE SATELLITE TO ANOTHER

The invention relates to a telecommunications method and system using non-geosynchronous satellites.

Until recently, satellites used for telecommunications have mainly been geosynchronous satellites. This has two drawbacks, however: firstly terrestrial coverage that is relatively limited and, secondly, and more importantly, signal propagation time that is not always compatible with real-time communications. Because the altitude of a geosynchronous satellite is 36 000 km, the minimum time for a signal to travel from the Earth to the satellite and from the satellite to the Earth is approximately 250 ms. Also, free space propagation losses over this distance are not favorable to achieving high capacity.

To increase the coverage of systems using relay satellites and, more importantly, to reduce the propagation time, telecommunications systems have been developed using a constellation of satellites in low Earth orbit or in medium Earth orbit. The altitudes of the orbits of such satellites are from 800 to 1 500 km and the orbits are chosen so that practically all of the surface of the Earth is covered, i.e. so that at any time at least one satellite can be seen from anywhere on the Earth (with the exception of polar areas on a few occasions).

Because the satellites are not geosynchronous, from any point on the Earth the same satellite can be seen for only a limited time period, at most of the order of 15 minutes. Because of this, the telecommunications system is designed so that, for a terrestrial user, as one satellite leaves the area of visibility there is another satellite ready to take over the call.

Transferring a call from one satellite to another is sometimes referred to as "handing over" or "handing off"

the call.

In prior art non-geosynchronous satellite telecommunications systems used until now, handover is effected individually for each terminal. To this end, means for detecting call quality, for example the signal-to-noise ratio, between the terminal and the satellites in view are provided in each terminal, i.e. in each equipment unit designed to receive and send calls. Control or management means, located in a central station, for example, command the handover of calls sent and received by the terminal from a first satellite to a second satellite when the quality of calls relayed by the first satellite falls below a pre-determined threshold and when the quality of calls relayed by the second satellite is above that threshold.

The invention stems from the observation that this type of handover, effected individually for each terminal, causes difficult problems in managing the allocation of call resources. Call resources in a telecommunications system are intrinsically limited and must be managed continuously so that the system can handle the maximum data or calls.

The term "resources" refers to the power of the transmitter and to the characteristics of the transmitted signals for allowing a large number of simultaneous calls at all times. These characteristics of the signals can be their polarization, different carrier frequencies, time division multiplexing, and various codes. All this is known in the art. Multiplexing in time is known as time division multiple access (TDMA) and separating signals by means of their codes is known as code division multiple access (CDMA).

Accordingly, on each handover of a call involving one terminal from one satellite to another, the telecommunications system must reapportion its resources, using a complex program, in particular because at the time of the handover practically all the parameters of a

call (power, carrier frequency, time and/or code and polarization), are liable to change. The complexity of managing all this naturally increases as the number of users of the telecommunications system increases.

The invention remedies these drawbacks.

It is characterized in that, the telecommunications system being such that the communication domain is divided into terrestrial areas, inside each area the periods of handover of stationary (fixed) terminals in the area is commanded using predetermined data concerning the times during which at least two satellites are simultaneously visible in the area or in a portion of the area. For example, one satellite is moving away from the area and the other is approaching said area.

In other words, the invention exploits the deterministic (i.e. known in advance) character of the orbits of the satellites and the times at which they are pointed toward the area concerned.

Call handover can therefore be managed collectively, to distribute call resources optimally. What is more, as the period of common visibility of the two satellites is known in advance, there is no need for continuous monitoring of the presence of a second satellite.

The invention is particularly useful in the case of a telecommunications system for which the terrestrial areas are fixed, rather than mobile, since in this case the number of handovers to be effected simultaneously is large.

One embodiment, in which the terminals and/or the central station and/or the satellites include directional antennas, exploits predefined data concerning the times at which at least two satellites are simultaneously visible in the area, or in a portion of the area, in order to point a second antenna or a second set of antennas toward the satellite that will take over the calls.

It should be noted that, if directional antennas are

used, the same frequencies can be used simultaneously in the same terminal or in the same central station if the two satellites transmit beams with sufficient angular separation.

In one embodiment the periods of handover from one satellite to another are commanded so that they can be distributed over all the terminals during the period of double visibility. It is therefore possible to distribute over this period the processing power necessary to effect the handovers and the corresponding exchanges of signaling between the terminals and the network.

In one embodiment, the individual handover periods are distributed so that the resources used by each satellite remain substantially constant at all times.

Pre-programmed distribution of handovers can be combined with real-time management of calls on an individual basis.

In some particular circumstances it may be necessary to depart from the collective handover period for each terminal. For example, a link for a terminal or a set of terminals may fail because of an obstacle on the propagation path between the terminal and the satellite.

Traffic peaks can also occur, for example, leading to the temporary need for a distribution of resources between satellites departing from the pre-programmed distribution. Nevertheless, as this possibility of departure from the pre-programmed management scheme occurs relatively infrequently, pre-programmed management retains all of the advantages referred to above.

In another aspect, that can be used independently of its aspects mentioned above, the invention provides features facilitating handover of calls from one satellite to another.

A first of these features consists of dividing all the carrier frequency resources into non-contiguous subsets such that, when a call is handed over from one

satellite to another, the carrier resources of the two calls belong to the same subset.

Thus grouping the carriers into subsets significantly facilitates call handover management and the design of the management station provided in each area. The management station includes a switch, as it were, for allocating carriers, and separating the carriers into subsets means that the switch can be divided into the same number of switching units as there are subsets. In this way each switching unit is of simpler design than a switching unit having to process all the carriers simultaneously.

In an aspect that can also be used independently of its other aspects described above, the invention relates to the level at which the data of a call is separated in order to effect the handover.

The level at which the data of a call is separated in order to effect handover from one satellite to another is preferably downstream of the multiplexing of the cells (more generally, the multiplexing of the user signals), in which case calls are handed over from a carrier provided for one satellite to another carrier provided for another satellite. The handover is particularly simple to effect and the handover method is very suitable for handing over a multiplicity of calls.

Multiplexing cells or packets consists of distributing the cells or packets between frames including 16 time slots, a time slot corresponding to the duration of a cell. A plurality of cells is sent in each time slot. The various cells that are allocated to the same time slot are distinguished from each other by a resource, for example their code, their time slot or their carrier frequency.

It is assumed hereinafter that the cells or packets are distinguished from each other by their code and/or their time slot.

When handover is effected downstream of

multiplexing, a single mechanism is provided for allocating resources to cells. However, power control must be implemented on each path, because the attenuation can differ from one path to another.

With the above type of handover, it may be preferable to provide for simultaneous sending on the two paths during a cell time slot. This transition period is exploited to adjust the power on the new path because (the resources being the same on the two paths), before handover the cells of the current frame are sent at a given power on the first path and at zero power on the second path and after handover the cells are sent at zero power on the first path. Thus it is preferable to ensure a gentle transition in terms of the power resource on the two paths. This being the case, during the transition period, the resources must be duplicated, one carrier frequency being allocated to one path and another carrier frequency to the other path. What is more, given that the cells are allocated collectively for the two paths, it is also necessary to satisfy an additional condition, namely that the sum of the powers of the cells must not exceed the authorized maximum power on each path during the same cell time slot.

This being so, the handover time clearly depends on the location of the terminal.

The invention generally provides a telecommunications method using non-geostationary Earth satellites and in which the Earth is divided into areas inside which calls involving fixed (stationary)terminals in said area are relayed by a management station and each terminal and the management station communicate via a satellite, another satellite taking over a call when the former satellite is no longer used, which telecommunications method is characterized in that commanding handover of calls from one satellite to another makes use of predetermined times during which at least two satellites are simultaneously visible from the

area or from a portion of the area.

In one embodiment handover of calls involving the terminals from one satellite to another is commanded from the management station.

Call handovers are preferably commanded collectively for a plurality of terminals.

In one embodiment, in determining the handover time for each terminal, allowance is made for the power available and/or the availability of communication resources.

In one embodiment handover times are commanded so that they can be distributed over all the terminals during the period of double visibility of the satellites.

In one embodiment the handover times are distributed so that the resources used by each satellite are substantially the same.

The times of handover of calls from one satellite to another are predefined for each terminal, for example.

In one embodiment call quality is monitored for each terminal and a call is handed over to another satellite ahead of time if the call quality for a terminal falls below a predetermined threshold, for example because of masking.

In one embodiment a call is handed over to another satellite ahead of time if said other satellite provides a communication capacity greater than that of the former satellite.

The terrestrial areas are preferably fixed.

In one embodiment the resources allocated to a terminal for a satellite include a carrier frequency and a plurality of codes, especially Hadamard sequences, and/or time slots.

In one embodiment a single system for allocating resources is provided in each terminal and/or the management station and said resources are duplicated during a handover period.

In one embodiment two cells, packets or other

signals to be relayed simultaneously by two different satellites have different carrier frequencies and preferably the same codes.

In one embodiment zero power is allocated to signals on the second path before handover and zero power is allocated to signals on the first path after handover.

In one embodiment non-zero powers are allocated to both sets of cells or packets during a transition period, for example equal to a cell or packet time slot.

In one embodiment the powers allocated to the duplicated cells or packets are monitored.

The present invention further provides a terminal for a telecommunications system using non-geosynchronous Earth satellites and in which terrestrial areas are defined, each terminal in an area communicating with the telecommunications system via a management station in that area, calls between the management station and the terminal being relayed via a satellite, and means being provided in each terminal for commanding handover of calls from one satellite to another satellite, which terminal is characterized in that handover means in said terminal include means for receiving handover command signals.

In one embodiment the means for commanding handover make use of predetermined times at which at least two satellites are simultaneously visible in the area or in a portion of the area.

In one embodiment the terminal includes means for measuring the quality of the link to each satellite and means for bringing handover forward if the quality of the link to the satellite that is moving away falls below a predetermined threshold.

In one embodiment the terminal includes two directional antennas, one intended to be pointed toward one satellite and the other toward another satellite.

In one embodiment signals for commanding handover include signals for commanding pointing ahead of time of

the antenna intended to be pointed toward the satellite due to take over the call.

The present invention also provides a management station for a communication system in which terrestrial areas are defined, each terminal in an area communicating with the telecommunications system via a management station in that area, calls between the management station and the terminals being relayed via a satellite, and means being provided in each terminal for commanding handover of calls from a first satellite to a second satellite, which management station is characterized in that it includes means for commanding handover of calls involving stationary terminals in the area, or in a portion of the area, using predetermined times at which at least two satellites are visible simultaneously in that area or in a portion of that area.

In one embodiment the management station includes means for determining individual handover times for each terminal as a function of the allocation of power and/or communication resources.

In one embodiment the periods of handover from one satellite to another are commanded so that they can be distributed over all of the terminals during the period of double visibility.

In one embodiment the management station includes a system for allocating the terminals carrier frequencies divided into non-contiguous subsets, two carriers from the same subset being chosen to hand over a call from one satellite to another.

Other features and advantages of the invention will become apparent from the following description of embodiments of the invention, which is given with reference to the accompanying drawings, in which:

Figure 1 is a diagram of a telecommunications system to which the invention applies,

Figures 2a to 2f are diagrams showing various instances of satellite visibility and periods of

handovers effected by the method according to the invention,

Figure 3a shows an area of a system of the Figure 1 type, indicating beams transmitted by a plurality of satellites,

Figure 3b is a diagram analogous to those of figures 2a to 2f and corresponding to the situation shown in Figure 3a,

Figure 4 is a diagram showing one example of the method of programming beams transmitted by send/receive means on board satellites of the Figure 1 system,

Figure 5 is a diagram showing one example of a carrier frequency distribution used in the method according to the invention,

Figure 6 is a diagram of a management station of the Figure 1 system employing the method shown in Figure 5, and

Figure 7 is a diagram showing one example of the level at which handover can be effected in a terminal or a management station.

The embodiment of the invention described next with reference to the figures relates to a telecommunications system using a constellation of satellites orbiting the Earth at an altitude of approximately 1 450 km. The terrestrial surface is divided into substantially circular areas with a diameter of 700 km. Within each area 20_i (Figure 1) is a management station 22, which is located at the center of the area, for example, and a plurality of terminals 24_1, 24_2, 24_3, 24_4, etc. The management station 22 is connected to a terrestrial or other type of communication network (not shown).

All the calls sent or received by a terminal 24_i pass through the management station 22 and calls between each terminal and the station 22 are relayed by a satellite S_1 or S_2. In other words, in the example shown in Figure 1, a call between a terminal 24_i and a user or the network to which the station 22 is connected is

relayed by a satellite S_1 or S_2 and passes through the management station 22; a call between a terminal 24_1 and another terminal 24_3 or 24_4 remote from the terminal 24_1 is relayed by the satellite S_1, passes through the station 22 and is relayed by the satellite S_2 or S_1.

Equipment (not shown) activated on a pre-programmed basis is provided on each satellite for receiving and forwarding calls. In one example, each satellite has control means such that several terrestrial areas are "illuminated" at a time, and the control process is such that, as it moves, the satellite modifies the beam so that it always impinges on the area concerned during the satellite's active transit across the area. The maximum duration of this transit is approximately 15 minutes.

Because the period of visibility of a satellite from a given area is limited, the constellation of satellites must be such that when one satellite is approaching the end of its period of visibility it is replaced by another satellite to take over the call. Because this type of telecommunications system is generally intended for high-quality calls, it is necessary to prevent the quality of the calls from being affected by handing the calls over from one satellite to another. In other words, the system is organized so that, at least at the time when a satellite relaying a call is about to leave the area of visibility, another satellite is simultaneously in the area of visibility and remains in it when the first one is no longer visible.

In one embodiment, satellite visibility is predetermined, as a function of the elevation of the satellite relative to the management station 22 and to each terminal 24_i. The minimum elevation for the management station to be able to see a satellite is 5° and the minimum elevation for a terminal to be able to see a satellite is 10°. In this embodiment, because of the dimensions of the area and the altitude of the satellites, all the terminals 24_i in the area can see a

satellite when it has an elevation of 14.4° relative to the station 22. On the other hand, none of the terminals can see the satellite when its elevation relative to the station 22 is less than 6.1°.

Accordingly, only a portion of the area 20_i can see the satellite when the elevation of the satellite relative to the station 22 is from 6.1° to 14.4°.

Given the high cost of each satellite and its onboard equipment, the number of satellites must be limited. For this reason it is generally not possible, in all the areas 20_i, when the elevation one satellite relative to the management station is beginning to decrease toward 14.4°, for another satellite to have an elevation relative to the same station of at least the same value, and to retain that minimum elevation, or a greater elevation, after the elevation of the setting satellite has fallen below 14.4°. In other words, it is not always possible to provide for a satellite visible to all the terminals in the area to be replaced immediately by another satellite visible to all the terminals in the area.

In fact, as explained later, very diverse situations can arise during which the mechanisms for effecting handover from one satellite to another must intervene. The telecommunications system must nevertheless take account of all these possibilities in commanding the turning on or activation of the sending and receiving means on board each satellite.

The invention optimizes the management of communication resources at all times by exploiting this system management function to command the handing over of calls from one satellite to another.

To this end, handover of calls from each terminal and/or each management station is effected by a control system which is centralized in the management station and which decides on handovers as a function of pre-programmed activation of the sending and receiving means

on board each satellite.

Thus management of call resources can be balanced during handover.

For handover purposes, each terminal has two directional antennas, one of which is pointed toward the current satellite and the other of which, prior to handover, is pointed toward the satellite that is due to take over the call.

Note that in the above telecommunications system, in which the pencil beams transmitted by the satellites are fixed on the terrestrial areas, handover must be effected simultaneously for a large number of terminals and during a relatively short time period. Also, the need for handover is not regularly distributed in time, but sporadic.

Figures 2a to 2f show various situations of handing over calls from one satellite to another. In each diagram, each line represents the elevation of a satellite as a function of time $\underline{t}$. A continuous line corresponds to a satellite whose elevation relative to the management station is greater than 14.4° and a dashed line corresponds to an elevation relative to the management station from 6.1° to 14.4°.

In the Figure 2a example, there is a period T_1 in which the elevation of both satellites S_1 and S_2 is greater than 14.4°. However, in this system calls are handed over from the setting satellite S_1 to the rising satellite S_2 in a portion T_{gW} of the period T_1.

The handover of calls is commanded from the management station of the area, for example. In this case, handover from the satellite S_1 to the satellite S_2 is commanded for all the terminals of the area during the time T_{gW}.

This collective command optimizes management of the distribution of communication resources and power, as much with regard to the terminals of the area as with regard to the satellites and the whole of the

telecommunications system. Handover for the various terminals can be uniformly distributed over the period T_{gw}, for example.

In the example, each terminal has two mobile directional antennas for tracking the satellites. One of the two antennas is not used outside handover periods. The unused antenna is pointed toward the satellite S_2 in advance of handover.

In the situation shown in Figure 2b, the setting satellite S_1 has an elevation from 6.1° to 14.4° in a period T_2 during which the rising satellite S_2 has an elevation greater than 14.4° and the satellites S_1 and S_2 both have an elevation greater than 14.4° during a period T_d preceding the period T_2. In this case, handover can be effected during a period T_{gw} equal to the sum of the periods T_d and T_2.

Note that during the period T_d the terminals for which handover of calls from the satellite S_1 to the satellite S_2 is commanded are at least those for which the satellite S_1 has an insufficient elevation during the period T_2.

The situation shown in Figure 2c is analogous to that shown in Figure 2b. It differs therefrom only in that the rising satellite S_2 has a period T_3 at the beginning of its period of visibility from the area during which its elevation is from 6.1° to 14.4°. Both satellites have an elevation greater than 14.4° during a period T'_d at the end of the period of visibility of the satellite S_1. The period T_{gw} for commanding handover comprises a portion of the period T_3 and the period T'_d.

Thus in the example shown in Figure 2d there is no period during which both satellites S_1 and S_2 simultaneously have an elevation greater than 14.4°. On the other hand, both satellites are visible at all times from the management station during a period T_{gw} that includes a first period T_4 during which the satellite S_1 has an elevation greater than 14.4° relative to the

management station, although the satellite S_2 has an elevation less than 14.4° (but greater than 6.1°). During the second period T_5 both satellites have elevations from 6.1° to 14.4° and, finally, during the third period T_6, the elevation of the satellite S_1 is from 6.1° to 14.4° and that of the satellite S_2 is greater than 14.4°. In this case, as in Figures 2b and 2c, handover can be effected progressively for the various terminals.

In the example shown in Figure 2e, there is no period of common visibility for handing over all the calls from the setting satellite S_1 to the rising satellite S_2.

In this case a third satellite S_3 is used which, in this example, has an elevation from 6.1° to 14.4° during the handover period T_{ho}. Also, the visibility of the satellites S_1, S_2 and S_3 from the area is such that during a period $T_{gW1,2}$ calls are handed over from the satellite S_1 to the satellite S_2 for the terminals in the portion of the area from which the satellite S_2 and the satellite S_1 are visible and from which the satellite S_2 will remain visible.

During a period $T_{gW1,3}$ which, in this example, coincides with the greater portion of the period $T_{gW1,2}$, calls are handed over from the satellite S_1 to the satellite S_3 for terminals in the remaining portion of the area, from which both satellites are visible. In this case, of course, the satellite S_3 remains visible from the remaining portion of the area up to the start of the period in which the satellite S_2 has an elevation greater than 14.4°. Calls involving these terminals are handed over from the satellite S_3 to the satellite S_2 during a period $T_{gW3,2}$ which, in this example, is separate from the periods $T_{gW1,2}$ and $T_{gW1,3}$.

In the example shown in Figure 2f, handover from a satellite S_1 to a satellite S_4 during a period T_{ho} involves two other satellites S_2 and S_3. Various portions of the zone are handed over first from the satellite S_1 to the

satellite S_2 during a period $T_{gw1,2}$ and another portion of the zone is handed over from the satellite S_1 to the satellite S_3 during a period $T_{gw1,3}$. Handover from the satellite S_2 to the satellite S_4 and from the satellite S_3 to the satellite S_4 is effected during respective periods $T_{gw2,4}$, $T_{gw3,4}$.

To explain more clearly the various situations that can arise in a terrestrial area, Figure 3a shows an area 20 and the tracks of the beams from the antennas of the three satellites S_1, S_2 and S_3 across the area and in its vicinity. Figure 3b is a diagram showing the visibility of the satellites in a form analogous to the diagrams of Figures 2a to 2f.

In the situation shown in Figure 3a, the beam from the antennas of the rising satellite S_2 occupies the portion of the area 20 that is on the concave side of a line 30 representing the edge of the beam transmitted by the satellite S_2. Also, at this time, the satellite S_1 is illuminating the portion of the area 20 that is on the concave side of a line 32. Thus it can be seen that, in this situation, there is a region 34 that is covered neither by the satellite S_1 nor by the satellite S_2, but is covered by the satellite S_3, the edge of whose beam is represented by a line 36.

The arrows f_1, f_2 and f_3 correspond to the direction of movement of the respective satellites S_1, S_2 and S_3. Clearly, calls involving the corresponding terminals have been handed over to the satellite S_3 before the region 34 is no longer covered by the beam from the satellite S_1, and afterwards, when the region 34 is covered by the beam from the satellite S_2, calls involving the terminals in this region are handed over to the satellite S_2.

In the Figure 4 diagram, the horizontal segments each represent a period of visibility of a particular satellite from an area. In practice, the equipment on board the satellites is controlled so that it illuminates the corresponding area over the periods indicated.

The diagram represents scheduling based on a period of thirty hours and effected in the management station, for example.

In this diagram, the various segments, i.e. the various passages of the satellites over the area concerned, have been grouped into three sets E_1, E_2 and E_3. Each set constitutes a path enabling continuity of calls in time, as it were, despite the appearance and disappearance of the satellites.

In the set E_1, each call can be handed over from one satellite to the next. Likewise in the set E_2. In contrast, in the set E_3, there are portions of the area in which terminals cannot be handed over from one satellite of the set to another satellite of the same set. This applies to handover from the satellite S_5 to the satellite S_6, for example. In this case, calls involving terminals that cannot be handed over from the satellite S_5 to the satellite S_6 are handed over from the satellite S_5 to the satellite S_7 from the set E_1 (arrow F) and calls involving those terminals continue in the set E_1.

To balance the load, it is then possible to hand over to the path E_3 calls involving terminals that are allocated to the path E_1, which calls can then, of course, given the geographical position of the terminals, be handed over from the satellite S_5 to the satellite S_6 (arrow F').

Similarly, in the set E_3 handover of calls from the satellite S_8 to the satellite S_9 is not possible for all the terminals. For this reason, and in an analogous fashion, calls involving terminals that cannot be handed over from the satellite S_8 to the satellite S_9 are handed over to a satellite S_{10} of the set E_2 (arrow F_1). Other calls are handed over from the satellite S_{10} to the satellite S_8 (arrow F'_1).

Call handover from one satellite to another for various terminals inside the area is made possible by the predetermined programming of the beams on board the

satellites, reflecting the deterministic nature of the trajectories of the satellites, both in space and in time.

Although the invention exploits the deterministic nature of the trajectory of the satellites and of the control of the equipment on board the satellites, it is not incompatible with individual management of handover to solve particular or temporary problems of certain terminals. For example, should a terminal normally intended to communicate via a given satellite be unable to do so at a particular time because of masking, for example because of a building or an unexpected obstacle in the field of the antenna, or because of bad weather, the call can be switched to another satellite and the control system in the management station 22 can take account of the masking that has been detected and subsequently hand over the call to satellites that are not masked.

Consider another example: should the call capacity (expressed in megabits/second) of the satellite allocated to a terminal be insufficient at a particular time, because of a momentary overload at the terminal, calls can temporarily be handed over to another satellite having a greater call capacity. It is also possible to bring forward the handover to the next satellite, if it provides a greater call capacity.

Another feature of the invention is described next with reference to Figures 5 and 6, namely distribution of the resources between satellites allocated to an area 20 in a manner that simplifies the implementation of the management station 22.

Before proceeding with this description, it is as well to bear in mind that in a telecommunications system according to the invention all terminals must be able to communicate with each other via the management station and must also be able to communicate with the terminals of a terrestrial or other network connected to the

management station 22. Also, each call or each packet must be able to utilize any resource of the network, i.e. any carrier frequency of any satellite.

This constraint causes difficult resource management problems.

To solve these problems in a manner that simplifies management by the station 22 (see above), the set of carriers available to the telecommunications system is divided into a plurality of subsets or bundles B_1, B_2, B_3 (Figure 5), etc. so that handover from one satellite to another satellite of calls involving a terminal or the management station can be effected only by handing over the calls from a carrier of one subset to another carrier of the same subset. In this way a terminal is associated with only one subset of carriers.

Figure 5 symbolizes by means of rectangles the resources B_1 for a terminal 20_i. The figure shows that, in this case, three satellites S_1, S_2 and S_3 are visible from the terminal 20_i, which is allocated the subset B_1 including the carriers P_1 to P_q. The carriers P_1 to P_n are allocated to the satellite S_1, the carriers P_{n+1} to P_p are allocated to the satellite S_2 and the carriers P_{p+1} to P_q are allocated to the satellite S_3.

Each of the satellites S_1, S_2, S_3 can also communicate using carrier frequencies that are not in the subset B_1, for example frequencies in the subset B_2. However, these sub-carriers will not be used for calls involving the terminal 20_i, but for calls involving other terminals, such as the terminal 20_j.

Accordingly, when a call involving the terminal 20_i which is relayed via the satellite S_1 on the carrier frequency P_2 must be handed over to the satellite S_2, the carrier frequency used for that call involving the terminal 20_i when it is relayed via the satellite S_2 is chosen from the carrier frequencies P_{n+1} to P_p in the subset B_1.

The management station 22 includes a system 42

(Figure 6) for switching traffic in the station 22 by processing its carriers. The system 42 is divided into the same number of portions 42_1, 42_2, etc. as there are subsets B_1, B_2, etc. The system 42 effects the handover of calls from one satellite to another and also provides the connection to other networks, for example terrestrial networks. Under these conditions, each portion 42_1, 42_2, 42_3 of the system 42 includes an input/output 44_1, 44_2, etc. connected to the terrestrial network(s) and a plurality of inputs/outputs 46_1, 48_1, etc. In each portion 42_i, the number of inputs/outputs 46_i, 48_i is equal to the number of carriers in the corresponding subset B_i.

Furthermore, the station 22 includes a number N of modems 50_1 to 50_n equal to the number of carriers. Each modem is associated with an antenna 52_1, 52_2, etc.

The inputs/outputs 46_i, 48_i, etc. are connected to the modems 50_1, 50_2, etc. via a switching matrix 60.

If, as shown here, calls involving a terminal 20_i are relayed at a particular time by the satellite at which the antenna 52_1 is pointed and on the carrier from the subset B_1 corresponding to the output 46_1 of the portion 42_1 of the system 42, and if the calls must be handed over to the satellite at which the antenna 52_2 is pointed, then, in the portion 42_1 of the system, the calls are handed over (arrow HO) from the input/output 46_1 to the input/output 48_1, and the input/output 48_1 is connected by the matrix 60 to the modem 50_2 and therefore to the antenna 52_2.

Clearly this organization of the carriers in subsets simplifies the organization of the system 42, which is made up of a set of portions or modules 42_1, 42_2, etc. which are all similar to each other.

The invention also relates to the level at which call handover can be effected. This use of the term "level" refers to the fact that handover can be effected downstream of the buffer memories in which the ATM cells

are waiting, instead of upstream of it. In this embodiment, handover is effected after the allocation (multiplexing) of resources.

If handover is effected downstream of multiplexing, it is referred to as "physical" handover, because it occurs close to the physical transmission resources.

Accordingly, in the embodiment shown in Figure 7, a handover 82 is effected at the physical level, i.e. after multiplexing the cells. Thus a set of buffer memories 60, 62, …, 66 and distributor means 72 for distributing the resources 74 are provided.

Call switching 82 from one path to another is effected directly downstream of allocation of the resources 74. In other words, the same codes and/or time slots are allocated to each path. The carrier frequencies are different, however.

Each path has its own power control function, represented by a respective symbol 84_1 and 84_2. The power required for each path is not necessarily the same.

To ensure correct transition from the power of one path to that of another path, it is preferable to provide a transition period, corresponding to a frame, for example, during which the same resources in terms of codes and/or time slots are allocated simultaneously to both paths, with simultaneous sending of cells on both paths during a cell time slot. Prior to this transition period zero power is allocated to the second path and after this transition period zero power is allocated to the first path.

During the transition period, in which the cells are sent with a non-zero power simultaneously on both paths, it is necessary to monitor the power so that, for each path, the sum of the powers allocated to the cells does not exceed the maximum authorized power on that path. Because this condition is difficult to satisfy, the call handover time is generally different from one terminal to another.

To explain more clearly the mechanism for handing over a call from one path to another, the operations to be effected are described briefly below.

It must first be borne in mind that each terminal has two antennas. Accordingly, during a handover preparation phase, the standby antenna of each terminal is pointed at the satellite due to take over the call. This pointing can be effected even before activating the pencil beam of the latter satellite.

The demodulator is synchronized to the frequency in time, phase, and frequency after turning on the pencil beam.

Finally, the quality of the link with the second satellite is estimated during this preparatory phase.

The preparatory phase is followed by a waiting phase during which the terminal waits for a handover or changeover instruction from the central station. This waiting phase can be terminated ahead of time if the quality of the link on the path of the first satellite is suddenly degraded, for example. In this case, the calls are switched quickly to the second path.

During a third phase, the central station issues the handover or changeover instruction to the terminal. The terminal acknowledges reception of the instruction and at the same time provides a precise indication of the quality of the link with the second satellite, and the power of the call is adjusted. The changeover is effected after this third phase.